Commentaries

The Critical Review Process According to ISO 14040-43

An Analysis of the Standards and Experiences Gained in their Application*

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Abstract

Background. The critical review is an important, though not always well understood and correctly applied element of Life Cycle Assessment studies. It is the intention of this paper to analyse the relevant standards and to present personal experiences in conducting critical reviews.

Results and Discussion. A peer review for LCA-studies was first proposed in the SETAC guidelines 'A Code of Practice' (1993). The ISO standard 14040 (1997) describes three types of 'Critical review' which are optional in general, but mandatory 'for LCA studies used to make a comparative assertion that is disclosed to the public'. For this purpose, the most comprehensive form according to section 7.3.3, the panel method, has to be ('shall' in ISO terminology) be used. From personal experience, this method is found to be the most frequently performed in practice (60%), the average panel size being three experts. Large panels with more than 4 experts are rare.

Recommendation. Personal experience leads to supporting the recommendation by SETAC of the accompanying or 'interactive' critical review, which should be preferred, over the review '*a posteriori*', which offers considerable risks in regards to the duration and costs of an LCA study. ISO 14040, on the other hand, does not recommend one or the other way of performing the critical review.

Keywords: Critical review; comparative assertions; ISO 14040; SETAC code of practice

Introduction

Peer review in LCA is completely different from peer review in scientific journals [1,2]. It is not anonymous and – quite to the contrary – requires a close and open co-operation between the commissioner of an LCA study, the practitioner (very often a consulting firm) and the reviewer or the review team (panel). It is also much more time consuming and can be compared to review procedures of research projects, e.g. by governmental research organizations. Furthermore, also in contrast to journal review, not all data and information scrutinized will be published. The reviewed study is often not published at all and may serve political or marketing goals rather than scientific or technical ones. These political and commercial uses of LCA are foreseen in ISO 14040 [3], albeit not as part of the LCA, but rather as possible applications.

1 Peer Review according to SETAC Code of Practice

The first recommendation of a peer review in LCA was given in the SETAC guidelines for Life Cycle Assessment (1993) with the sub-title 'A code of practice' [4]. One of the reasons for the emphasis on peer review was a considerable misuse of comparative LCAs in the early times of LCA (ca. 1970–90), e.g. by using deliberately incompatible system boundaries and deriving evidently false claims from LCA-based results. This misuse also seems to have been the reason for other restrictive recommendations in the SETAC document [4] and, later, in the standards ISO 14040-43 [3,6,10,11]. Examples for such restrictive advices are the interdiction of weighting (valuation) in comparative assertions disclosed to the public (ISO 14042 [10]) and the low ranking of subjective or arbitrary allocation factors (instead, the clumsy system enlargement is ranked on place a/2 in ISO 14041, 6.5.3 [6])

The 'Code of Practice' gives two main reasons for performing a peer review: to enhance the quality and to enhance the credibility of an LCA study. Stricter than the later ISO standard, SETAC recommends an interactive or accompanying review.

Finally, SETAC gives advice on how to perform the review, whereas ISO deals mostly with the formal aspects. As with the rest of the Code, it can be stated that a very important input to the ISO 14040-43 series of standards was given.

2 Critical Review according to ISO 14040-43

The international standardisation process started in the same year in which the SETAC Code of Practice was published, i.e. in 1993 [5], and the first result was the framework norm ISO 14040 [3], published four years later. For the 'critical review', as it has been called since, ISO 14040 is the decisive standard; in the other LCA-standards ISO 14041-43 [6,10,11], the critical review is only mentioned occasionally (see below).

The critical review is first mentioned in paragraphs 5.1.2.4 and 2.1.2.5 (critical review considerations) [3]. In the last mentioned section one reads:

"Critical review is a technique to verify whether an LCA study has met the requirements of this international standard for methodology, data and reporting. Whether and how to conduct a critical review, as well as who conducts the review, **shall** be defined in the scope of the study."[1]

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[1] Here and later in the text: bold letters in citations are inserted by the author in order to emphasize important issues.

This wording defines the main purpose of a critical review and establishes the formal link with the scope definition which is elaborated in more detail in the subsequent standard 14041 [6]. The standard 14040 says further:

"In general, critical reviews of an LCA are optional and **may** utilize any of the review options outlined in 7.3. A critical review **shall** be conducted for LCA studies used to make a comparative assertion that is disclosed to the public and **shall** employ the critical review process outlined in 7.3.3."

The first sentence reads harmless: critical reviews are 'optional' and there are several possibilities to conduct a review. The second sentence, however, strictly demands for a critical review in its toughest form, in a wording which became famous in the LCA community. 'Shall' means in the ISO language 'must without exception' and indicates a very strong wording. This message is repeated in Section 7.1 in a chapter which is entirely devoted to critical review:

"…In order to decrease the likelihood of misunderstandings or negative effects on external interested parties, critical reviews **shall** be conducted on LCA studies where the results are used to support comparative assertions."

The emphasis of this paragraph is on avoiding 'misunderstandings', etc., an understatement. Much to the relief of all those conducting critical reviews according to section 7.3.3, we further read that "the fact that a critical review has been conducted should in no way imply an endorsement of any comparative assertion that is based on an LCA study". Again, this wording shows the firm determination of the authors of ISO 14040 to avoid any misuse of LCA, e.g. in marketing or for policy making, by the use of LCA-based claims that are not well and scientifically founded.

The most important section 7.3.3 is formulated in an intriguing way, insofar as there is an apparent contradiction between the title and the text of the section. The title of paragraph 7.3.3 is 'Review by interested parties'. The standard clearly says that the commissioner has to 'select' (i.e. invite) an 'external independent expert' to act as chairperson of a review panel:

"An external independent expert is selected by the original study commissioner to act as chairperson of a review panel. Based on the goal, scope and budget available for the review, the chairperson selects other independent qualified reviewers."

According to the following sentence, however, the inclusion of 'other interested parties' besides the experts is optional, as can be seen from the very weak 'may include':

"This panel **may** include other interested parties that will be affected by conclusions drawn from the LCA study, such as government agencies, non-governmental groups, or competitors."

As will be seen in section 5, large panels are rare in practice for financial reasons and probably also for the sake of confidentiality. Comprehensive LCAs used in the context of political decisions often have advisory boards including interested parties, such as representatives of industry associations, environmental and consumer protection groups, etc.; therefore, there is no or less need to include them in the review panel as well (e.g. [7,8]). The critical review panel or at least the chairperson is frequently invited to attend the advisory board meetings. In another variant, project presentations by the practitioner are combined with advisory board meetings and followed by a review panel meeting in a small circle. Fava and Pomper [22] describe a tiered, interactive critical review and very positive experiences gained in this procedure.

The question, whether an '*a posteriori*' or an accompanying ('interactive') [4] critical review is to be preferred, is not addressed in ISO 14040. Compared to the SETAC guidelines [4], ISO 14040 is less demanding and more flexible in this point.

There is a strong statement in the standard that the review statement, the review report and any written comments by the commissioner and/or the practitioner "**shall** be included in the LCA study report."

There are two other, less demanding modes of critical review: The internal review (7.3.1) and the external review by an independent expert (7.3.2). The review following 7.3.1 could be conducted via internal quality control in the commissioning company. It is said in ISO 14040 that the reviewers have to be independent on the LCA-team (be it external or internal). For the review following 7.3.2, in principle the same requirements apply as for chair persons in the panel mode (7.3.3), although the activity is in general less visible. The review statement is a part of the LCA study report in all variants of performance. A review according to 7.3.1 or 7.3.2 may be published together with the LCA study report, if the study does **not** contain comparative assertions (requiring a review according to 7.3.3), e.g. in some cradle-to-factory gate studies or LCIs (e.g. [9]).

The main duty of the reviewers is laid down in ISO 14040, 'General description of critical reviews' (7.1) and applies to all forms of critical review (7.3.1 to 7.3.3):

"The critical review process shall ensure that:

- the methods used to carry out the LCA are consistent with this international Standard;
- the methods used to carry out the LCA are scientifically and technically valid;
- the data used are appropriate and reasonable in relation to the goal of the study;
- the interpretations reflect the limitations identified and the goal of the study;
- the study report is transparent and consistent."

These five points clearly define what has to be studied in the critical review and also serve very well in structuring the core element of any review report according to ISO 14040, the review statement.

The critical review is also treated in a little section or paragraph in each of the detailed standards ISO 14041 [6], 14042 [10] and 14043 [11]:

- ISO 14041: 5.3.7
- ISO 14042: 10.3
- ISO 14043: 9.2

In most cases, the text only reaffirms the prescriptions of the framework standard 14040 [3], whose relevant sections are quoted. Only the Life Cycle Impact Assessment (LCIA) standard ISO 14042 [10] gives in section 10.3 a new statement on the necessary qualifications of the reviewers related to environmental sciences:

"For LCIA, the expertise of reviewers in the scientific disciplines relevant to the important categories of the study, in addition to other expertise of interest, **shall** be considered."

This item is important, since it is the only clear statement that the critical review requires expert knowledge in the environmental sciences and is by no means a routine work. In this connection it should be mentioned that a 'certification' of LCA-studies, as occasionally suggested and even practised (e.g. [12]), **has no foundation at all in ISO 14040-43.**

3 Effect of Critical Review on Quality and Credibility

The following section mostly deals with critical reviews according to ISO 14040, section 7.3.3, but similar positive effects can also be expected from weaker forms of review.

Many prescriptions of the standards, especially in ISO 14043 (interpretation) [11], aim at securing the quality of LCA-studies. Since the critical review has to scrutinize the application of the standards, it automatically enhances the quality of the LCA. This can hardly be seen in the final review reports, since most suggestions made by the panel members are taken into account by the practitioners concurrently. In nearly each review, the panel members produce long lists of errors and suggested improvements on the basis of their personal experiences and expertises.

Frequently, the review team members agree in a sort of specialisation, e.g.

- Compliance with standard/goal and scope;
- Data/inventory (LCI);
- Life cycle impact assessment (LCIA);
- Management of the review process.

Each member of the panel reads the whole report, but the depth of the critical reading may and should differ. Sometimes, one member of the review team is a data specialist for the product or production process which is in the focus of the study; this member has not necessarily to be an LCA expert, although it is usually better that all members are familiar with this technique.

Since the quality to be achieved in an LCA study depends on the goal and scope definition, there is no general scheme for assessing the quality. This has to be elaborated in discussions within the panel and/or with the practitioner and possibly the advisory group and the commissioner.

The quality of the review as well as its credibility depends to a large extent on the communication and co-operation between the three players: commissioner, practitioner and review panel (the 'review triangle') .

Especially the chairperson of the review panel, the representative of the commissioner, and the LCA-project leader have to co-operate closely. From my personal experience, I can say that it is more difficult to conduct a critical review if the commissioner does not participate in the review process actively (the practitioner always has to, only in case of an '*a posteriori* review', the practitioner may not be available). If the 'review triangle'works, and especially so in an accompanying review, the commissioner hardly has a chance to push the study in a direction which might please his marketing people (hired gun effect). The review team effectively backs the practitioner and thus contributes to the credibility of the LCA-study. On the other hand, evidently, it also supports the commissioner in his wish for unbiased high-quality work.

Not only the practitioners, also the reviewers can loose their credibility and therefore both are highly interested in a correct performance of the LCA and the critical review process. Finally, the commissioner gets more for his money even if the results may differ from anticipated results, since only well performed LCAs can result in long-lasting improvements.

One important aspect concerning quality and credibility is access to original data. Actually, the confidentiality of sensitive data (see a recent criticism by Frischknecht [13]) is one important reason for conducting a critical review. Since not all data are published, or only in a highly aggregated form, the reviewers have to judge their quality and appropriateness by random samples. In order to do so, they have to have access to the data: commissioner and practitioner **must provide this access.** This may be complicated if third parties provide data and are not prepared to reveal confidential issues. This problem was encountered in an early review [14,15], where a subcontractor did not allow full access to some crucial data. This resulted in a delay of several months, additional sensitivity analyses and other activities not foreseen in the work plan. A lesson to be learned: sub-contractors have to be included in data transparency for the review team or at least for one member of the panel responsible for data quality. In my anecdotic case, the difficulties were finally overcome, mainly since the 'review triangle' worked perfectly.

In another critical review for an LCA-study [16,17], during which difficulties arose, the commissioner did not communicate with the review team, at least not directly. The triangle, in that case, collapsed into a line opposing rather than joining practitioner and review panel. However, also in this case the critical review process was finished correctly and, as an additional benefit, the end-of-life LCI-models developed by the practitioner were fully published on request by the reviewers [18,19].

4 Effect of Critical Review on Project Duration (including cost)

Before discussing the effects of the critical review process on duration and cost of LCA-studies, one has to remember that there are two kinds of critical review: the accompanying or interactive one and the review *a posteriori*. The decision what kind of critical review will be performed may have consequences for the duration and finally the cost of the LCA-study.

In an accompanying critical review, the review team (in case of 7.3.3) is – to a certain degree – part of the project team, although a privileged one due to its independent status. The reviewers can and often do influence the study, except the goal itself: this is explicitely excluded in ISO 14040 section 7.1 [3]:

"Since this International Standard does not specify requirements on the goals or uses of LCA, a critical review can neither verify nor validate the goals that are chosen for an LCA, or the uses to which LCA results are put."

The sooner the review team is included, the better for the duration of the project. The best time is when the draft goal and scope chapter is finished. In this phase it is still possible to propose major changes in the methodology, e.g. the allocation rules or strategies to avoid allocation. Since the review team can influence the study (provided the suggestions are accepted by practitioner and commissioner) the results of the study will in general be acceptable and only minor changes will be required in the stage when the final report is written. In this case it typically takes only a few weeks (real time) to complete the review report, if the remaining improvements are quickly performed by the practitioner. The final conclusions, recommendations, the executive summary (if there is any) may be debated fiercely within the 'review triangle' in the final phase and take additional time.

In the case of a critical review *a posteriori* the situation is completely different. The review panel is in most cases confronted with the draft of the final report, where it is too late to change anything fundamentally. The first comments by the panel may be very critical. Now, in the final phase of the project, the project budget is in most cases spent, practitioner and commissioner have to negotiate who pays the additional work that might be required (personal note: my memory as project leader tells me that it is often the practitioner who pays). The review team is not a member of the overall project team and therefore can criticize the whole project and any amount of details 'from outside' without any psychological restraints. This is, of course, also the strong side of the review *a posteriori*: the fresh look from outside and the lack of restraint in being critical.

The delay in this type of critical review may amount to several months or even longer. It is a great risk for both the practitioner and the commissioner, which cannot be calculated at the beginning of the project. The accompanying critical review may involve a few reviewer days more, but it can be seen as a kind of 'insurance' against a possibly disastrous final phase.

This brings me to the question of the expenses needed for a critical review. I can try to do some statistics with my experience in 30 reviews over the last 10 years. In **Table 1**, first the type of review is shown using the classes ISO 14040, 7.3.3; ISO 14040 7.3.2 and 'no fixed rules' (not exactly following ISO, pre-ISO, company LCAs and similar studies). In the last case it should be remembered that the series of ISO standards was finished in the year 2000, but several reviews were performed in the years 1994–1999; more recently, there have been no reviews with 'no fixed rules'. As can be seen, most reviews, where I have been involved, have been conducted according to ISO 14040, 7.3.3, followed by ISO 14040, 7.3.2 .

Table 1: Critical review (a personal statistic)

Type of review	Number	[%]
Total	30	100
Method:		
Panel method acc. to 7.3.3	19	63
Expert review acc. to 7.3.2	6	20
No fixed rules	5	17
Timing:		
A posteriori	8	27
Accompanying/interactive	16	53
In between/unclear	6	20

Table 1 also shows that about half of the reviews have been performed in an interactive manner.

The average number of experts per review is 2.8 for the panel method (7.3.3) and 1.1 for the external expert method (7.3.2). There are a few borderline cases between 7.3.3 and 7.3.2, for instance if a large comparative study is not to be published. There is one published study from the US [22] which reports three reviewers and this is also the number I got from an experienced reviewer in the States as the typical size of a critical review. There are a few LCA-studies with more than 4 experts, e.g. seven (+ 2 review-editors) in a large plastic waste recycling and recovery study performed in Germany [23].

The most interesting question regarding the actual costs of the review cannot be answered with certainty since the data are lacking. There is an old rule of thumb that the cost of the review should not be higher than about 10% of the total cost of the study. This may be a fair limit for large studies, but is certainly too low for medium size and small studies with a budget of, say, 50,000 € or less. This roughly corresponds to the results of a discussion at the Hannover Symposium 1999 [24].

5 Final Remarks

According to ISO 14040, an LCA-study containing comparative assertions that are disclosed to the public has to ('shall') include a critical review according to the panel-method (§7.3.3). If the practitioner or the commissioner has additional comments (answers to the review comments), these, too, have to be published together with the main study, they are part of the whole report. This situation is clear, but a standard is not a law. An LCA-study can nevertheless be published if no claim is made that it has been conducted in (full) accordance with ISO 14040ff. The International Journal of Life Cycle Assessment, for instance, will accept such manuscripts if they are reviewed by at least two referees and according to the generally accepted rules of peer reviewing

in scientific journals. This publication can, of course, be cited as a scientific paper, even as an LCA, – but not as an LCA generated according to ISO. This may be too rigorous in some cases, e.g. in scientific papers that use comparisons between product systems only for the sake of method development and evaluation. Are such results 'comparative assertions'? And do such LCA-studies need a critical review in order to be in accordance with ISO 14040ff?

These questions may open a public debate. Letters to the editor and papers on actual critical reviews are welcome. Such a discussion may also give input to the ongoing revision/restructuring of the ISO LCA-standards [25,26].

References

[1] Klöpffer W, Heinrich A (1999): Peer Reviewing in a New Journal: Experiences from the First Three Years. Editorial in Int J LCA 4 (2) 61

[2] Klöpffer W (1997): Peer (Expert) Review According to SETAC and ISO 1440. Theory and Practice. Editorial in Int J LCA 2 (4) 183–184

[3] International Standard (ISO); Norme Européenne (CEN) (1997): Environmental management – Life cycle assessment: Principles and framework. ISO EN 14040

[4] Society of Environmental Toxicology and Chemistry (SETAC) (1993): Guidelines for Life-Cycle Assessment: A 'Code of Practice'. From the SETAC Workshop held at Sesimbra, Portugal, 31 March – 3 April 1993. Edition 1, Brussels and Pensacola (Florida)

[5] Marsmann M (2000): The ISO 14040 Family. Int J LCA 5, 317–318

[6] International Standard (ISO); Norme Européenne (CEN) (1998): Environmental management – Life cycle assessment: Goal and scope definition and inventory analysis. ISO EN 14041

[7] De Groot-van Dam A (chair), Gensch C-O; Klöpffer W, Klüppel H-J (2000): Abschließender Prüfbericht vom 25.7.2000, S 1–17. In: Plinke E, Schonert M, Meckel H, Detzel A, Giegrich J, Fehrenbach H, Ostermayer A, Schorb A, Heinisch J, Luxenhofer K, Schmitz S: Ökobilanz für Getränkeverpackungen II, Zwischenbericht (Phase 1) zum Forschungsvorhaben FKZ 296 92 504 des Umweltbundesamtes Berlin – Hauptteil (ISSN 0722-186X): UBA Texte 37/00, Berlin

[8] Klöpffer W, Grahl B, Gensch C-O (2002): Abschlussbericht zum Critical Review nach ISO 14040, Juli 2002, S 1–15. Anhang 1 in: Schonert M, Metz G, Detzel A, Giegrich J, Ostermayer A, Schorb A, Schmitz S: Ökobilanz für Getränkeverpackungen II, Phase 2. Forschungsbericht 103 50 504 UBA-FB 000363 des Umweltbundesamtes Berlin (ISSN 0722-186X): UBA Texte 51/02, Berlin

[9] Klöpffer W (1997): Critical Review Report on Life Cycle Inventories for the Production of Sodium Silicates. In: Fawer M, EMPA Bericht Nr. 241, St. Gallen 43–47

[10] International Standard (ISO); Norme Européenne (CEN) (2000): Environmental management – Life cycle assessment: Life cycle impact assessment. ISO EN 14042

[11] International Standard (ISO); Norme Européenne (CEN) (2000): Environmental management – Life cycle assessment: Interpretation. ISO EN 14043

[12] Giacomucci A, Baldo GL (1999): LCA Certification According to ISO 14040: First Experience. Int J LCA 4, 165–166

[13] Frischknecht R (2004): Transparency in LCA – a heretical request? Editorial in Int J LCA 9 (4) 211–213

[14] Klöpffer W, Grießhammer R, Sundström G (1995): Overview of the Scientific Peer Review of the European Life Cycle Inventory for Surfactant Production. Tenside Surf Det 32, 378–383

[15] Klöpffer W, Sundström G, Grießhammer R (1996): The Peer Reviewing Process – A Case Study: European Life Cycle Inventory for Surfactant Production. Int J LCA 1, 113–115

[16] Günther A, Langowski H-C (1997): Life Cycle Assessment Study on Resilient Floor Coverings. Int J LCA 2, 78–80

[17] Klöpffer W, Tukker A, Richter K (1998): Life Cycle Inventory with Impact Assessment. Expert Review, Final Report August 1997, 11 pp. In: Langowski H-C (ed), Life Cycle Assessment Study on Resilient Floorcoverings. For ERFMI (European Resilient Flooring Manufacturers' Institute). Fraunhofer IRB Verlag, ISBN 3-8167-5210-1, Stuttgart

[18] Kremer M, Goldhan G, Heyde M (1998): Waste Treatment in Product Specific Life Cycle Inventories. An Approach of Material-Related Modelling. Part I: Incineration. Int J LCA 3, 47–55

[19] Bez J, Heyde M, Goldhan G (1998): Waste Treatment in Product Specific Life Cycle Inventories. An Approach of Material-Related Modelling. Part II: Sanitary Landfill. Int J LCA 3, 100–105

[22] Fava J, Pomper S (1997): Life-Cycle Critical Review! Does it Work? Implementing a Critical Review Process as a Key Element of the Aluminium Beverage Container LCA. Int J LCA 2, 144–153

[23] Bontoux L, Papameletiou D (eds) (1999): Critical Review of the Study 'Recycling and Recovery of Plastics from Packaging in Domestic Waste – LCA-type analysis of different strategies'. In: Heyde M, Kremer M: LCA Documents Vol. 5, 183–194

[24] Stiftung Arbeit und Umwelt (ed.) (2000): Ökobilanzen & Produktverantwortung. Dokumentation. ISBN 3-89384-041-9. Hannover

[25] Committee Draft ISO TC 207/SC 5/WG6: ISO/CD 14040.2, 2004-09-30

[26] Committee Draft ISO TC 207/SC 5/WG6: ISO/CD 14044.2, 2004-09-30

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